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Complex monitoring of the sports training level depending on dietary lipids

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Abstract

The essential components of food are proteins, fats and fuels. In this paper, we will analyze one of the main macronutrients: fats, also called lipids.

First, dietary lipids are indeed exceptional sources of energy. In some organs, particularly the liver, heart and resting striated muscle, more than half of the energy required is supplied by triacylglycerols.

An essential particularity of the energy value of fats lies in the fact that they represent stores of energy substrates. Thanks to nutrition, funds (deposits) of energy resources accumulate in the body, which will be needed later.

In an adult's body, lipid reserves perform the same three basic functions: energy, thermal insulation, and defense against injury. The last two functions derive from the notion of "indispensable components of rational nutrition". At the same time, nutrition ensures, in interaction, many other aspects of the vital activity of living organisms.

Another function of subcutaneous fat reserves is somewhat forgotten, even if it is constantly perceived visually. It is about "softening the sharp corners" of the skeleton, which gives the body a fine roundness: the aesthetic function of the subcutaneous adipose tissue. It is often observed in performance sports that athletes have aesthetically unacceptable silhouettes with prominent anatomical contours of the bones.

In special living conditions, the priority function of reserve subcutaneous lipids becomes that of thermal insulation. It is about environments with low temperatures, being temporarily or permanently in an aquatic environment, etc. The vital activity of aquatic and semi-aquatic mammals directly depends on the existence of the subcutaneous adipose layer of thermal insulation [4].

Keywords: athletes, sports training, food, proteins, fats, carbohydrates, physical exertion.

Introduction.

In some exotic sports, the cold defense mechanisms are directly exploited on account of the subcutaneous adipose tissue: amateur swimmers in winter, professional long-distance swimmers, etc.

In sumo, considerable fat deposits protect the athletes from injury during falls on the hard surface.

The reserve lipids contain primarily triacylglycerols, 99% in humans. In general, reserve lipids are richer in saturated fatty acids than liver lipids, for example.

In the places where they are deposited, the lipids are in a liquid state. For example, subcutaneous fat consists mainly of saturated fatty acids. At the same time, this layer should have a state of liquid aggregation and therefore also contains unsaturated fatty acids. The minimum allowed content of unsaturated acids must be such as keeping them in a liquid state. On the other hand, the more saturated the lipids (their fatty acids), the higher their energy value during oxidation, but their liquid state is preserved at body temperature [5].

The chemical content of the fat deposits in each species of animal is relatively constant, but it can change with a sudden change in temperature or with the observance of a diet. According to some observations made on people, in whose diet unsaturated fatty acids (vegetable) predominated, after a rather long period, the content of subcutaneous fat was similar to that of food. Such cases are observed after long periods of starvation, when one's own fat reserves are exhausted, and vice versa: carbohydrate-based nutrition leads to the fact that the fats synthesized within it correspond to specific features and contain a minimum permissible amount of unsaturated fatty acids to preserve their liquid state.

The situation described above is exploited in animal husbandry. In the fertile years, in the feed of pigs, based on the use of oak acorns, in the final stage of fattening, feed with a high fat and protein content is added. This fact considerably improves the quality of meat and bacon.

Thus, regarding lipids in food, the notion of indispensable components of the food ration must be expanded, compared to traditional approaches. Namely, even reserve lipids are used to ensure essential functions: energy, thermal insulation, protection against mechanical actions, and the maintenance of reserve fats in a liquid state necessarily implies the consumption of unsaturated fatty acids in the diet.

This last requirement corresponds to a more general dietary approach regarding the mandatory character of the intake of unsaturated fatty acids in the diet.

The essence lies in the fact that lipids are not only a "storage" of energy, but also a universal biological material from which all cell membranes are built. Cell membranes are not a simple barrier that separates the contents of the cell from the environment that surrounds it. Through the membrane, the cell "communicates" with its environment, numerous proteins are "assembled" in the membrane: catalytic (i.e. enzymes), recognition (i.e. cell receptors) and various transport "microdevices".

Cell membrane lipids must naturally contain unsaturated fatty acids. At a minimum, membrane lipids must be in a quasi-liquid state. This is one more reason why it is necessary to consider lipids indispensable for a rational diet.

The role of lipids lies in the fact that many of them are characterized by an intense biological activity.

Among the relatively recent achievements in this field is the determination (structure deciphering), establishing the mechanisms of biological action of a new class of hormone-like compounds: the postaglandins. Precursors of the biosynthesis of these substances are polyunsaturated fatty acids.

Aspects regarding the importance and indispensability of lipids in food will be analyzed as follows.

The notion of lipids is somewhat uncertain. If food products or any other biological materials were processed consecutively using one or more organic solvents (ethanol, ether, chloroform, benzene, petroleum ether), then a certain part of this material will pass into a soluble state. The components of such a soluble fraction are called lipids.

The extracted fraction consists of numerous individual chemical compounds, which can be divided into whole classes of compounds: fatty acids; glycerin – containing lipids; non-glycerol lipids (sphingolipids, aliphatic alcohol, wax, terpenes, steroids); lipids associated with substances from other classes (lipoproteins, proteolipids, phosphatidopeptides, lipopolysaccharides) [6].

Fatty acids. The general formula of saturated fatty acids is: CH_3-$(CH_2)_n$-COOH. These are monocarboxylic acids because they contain an ionized carboxylic group (-COOH) and a non-polar cyclic unbranched hydrocarbon chain: CH_3-$(CH_2)_n$-

Natural fatty acids usually have an even number of carbon atoms, a fact determined by the peculiarities of their biosynthesis (and oxidation). Marginal (saturated) fatty acids do not have double bonds in their carboxyl chain. The melting point of fatty acids is higher, the more carbon atoms they contain. Triacylglycerols synthesized from fatty acids are similarly characterized: solid fats represent long chains, and liquid ones – short chains.

The numbering of carbon atoms begins with the carbon atom of the carboxyl group

```
           5          4          3          2          1
(-COOH): -CH2- CH2- CH2- CH2-COOH
```

Such numbering is important to correctly indicate the site(s) of the double bonds.

The angles between the valence bonds are 109^0, therefore the structural formula of fatty acids must be represented in the following way:

```
      CH2       CH2       CH2       CH2        CH2      CH2       COOH
      /  \      /  \      /  \      /  \       /  \     /  \      /
CH3       CH2       CH2       CH2        CH2      CH2       CH2
```

When double bonds are present, the linear structures of the molecules "tend" to take the form of open cyclic structures. This feature is important in prostaglandin biosynthesis (see below).

In food products and body tissues, the following marginal fatty acids are found more often and as a whole:

CH_3CH_2COOH – propanoic acid

$CH_3(CH_2)_2COOH$ – oleic acid

$CH_3(CH_2)_{12}COOH$ – miristic acid

$CH_3(CH_2)_{14}COOH$ – palmitic acid

$CH_3(CH_2)_{16}COOH$ – stearic acid

$CH_3(CH_2)_{18}COOH$ – arachidonic acid

$CH_3(CH_2)_{22}COOH$ – lignoceric acid.

Fatty acids are insoluble in water because most of their molecule is composed of CH_2 groups, which are hydrophobic, and only the carboxyl residue (-COOH) is hydrophilic. This characteristic determines the presence of lipids in all cell membranes. In typical food sources of fats (animal or vegetable origin), palmitic acid (C_{16}), stearic acid (C_{18}). Shorter chain fatty acids ($C_{12,14}$<), as well as those with long chains (>20…22) are found in smaller amounts or in trace form (see composition of food products).

In any diet containing lipids, there are no fatty acid deficits.

Unsaturated fatty acids (non-marginal). In fatty acid molecules there are double bonds: -CH=CH-, one or more. The existence of the double bond(s) is essential for their biological activity, participating in numerous biosynthetic processes.

Omnivorous animals, predators, humans are only able to a very small extent to carry out the endogenous biosynthesis of unsaturated fatty acids. Therefore, these food compounds are indispensable.

The position of the double bond is marked with the number of the carbon atom closest to the carboxyl group, which participates in the formation of this bond. For example: $CH_3(CH_3)_7CH=C^9H(CH_2)_7COOH$ – acid oleic.

Spatially, such a molecule forms a cis-isomer: H-C-$(CH_2)_7$-CH_3, H-C-$(CH_2)_7$-COOH represents the cisisomer of oleic acid.

The main unsaturated fatty acids have cis-configurations. We present the main C formulas$_{16}H_{30}$THE$_2$→$CH_3(CH_2)_5C^{10}H=C^9H(CH_2)_7COOH$ palmitoleic acid.

$CH_3(CH_2)_2COOH$ – oleic acid

$CH_3(CH_2)_{22}COOH$ – lignoceric acid

α - linoleic

γ - linoleic

$CH_3(CH_2)_{18}COOH$ – arachidonic acid

Above the respective carbon atoms are presented their numbers (counting starts from the COOH atom) between which there is a double bond.

A very intense biological activity is characteristic of polyunsaturated fatty acids, which have more than two double bonds. In particular, the most important role belongs to arachidonic acid, which has four double bonds. Namely, arachidonic acid serves as the unique and direct precursor of the endogenous syntheses of all prestaglandins (see the special section).

Animal and vegetable fats contain mono- and polyunsaturated fatty acids. But traces of arachidonic acid can also be detected in them. Exceptions are poultry meat, fat and eggs, fats from some fish species . For example, horse mackerel fat contains about 0.5% of arachidonic acid. Acids with six double bonds are also found in the fat of other fish (Skurihin I.M., 1984).

Food fats, which contain unsaturated fatty acids, must be stored under special conditions (at low temperatures, without O_2 etc.). Otherwise, a process called oil rancidity develops. The consumption of such products is strictly prohibited.

The indispensable character of unsaturated fatty acids is related to the fact that, for the formation of important biologically active compounds, they are absolutely necessary. For example: if, along with food, at least linoleic acid (two double bonds) enters the body, then, thanks to the desaturation reaction (removal of hydrogen ions) and the elongation of the carbon chain, arachidonic acid molecules can be synthesized again, according to the scheme:

CH_3CH_2COOH – propanoic acid

$CH_3(CH_2)_2COOH$ – oleic acid

$CH_3(CH_2)_{12}COOH$ – miristic acid

$CH_3(CH_2)_{14}COOH$ – palmitic acid

$CH_3(CH_2)_{16}COOH$ – stearic acid

$CH_3(CH_2)_{18}COOH$ – arachidonic acid

$CH_3(CH_2)_{22}COOH$ – lignoceric acid.

Linoleic Acid

↓ - 2H, i.e. desaturation s. of hydration

γ - linoleic

↓+C_2, i.e. chain elongation

Homo-γ-linoleic acid

↓ - 2H, i.e. saturation s. of hydration

Only the scheme was presented above, but in reality this is an extremely complex biosynthetic chain, within which the direct precursor of all prostaglandins is formed [7]. The entry of arachidonic acid into the body with food is very difficult, therefore, special mechanisms for its endogenous synthesis were necessary. A number of other essential non-essential fatty acids are found in common foods (Table 1).

Table 1. Lipid composition of fats and oils, g per 100g

The substances	**Unsalted butter**	**Pork lard**	**Refined sunflower oil**	**Cooking fat**	**Milk margarine**
Lipids (total)	82,50	99,70	99,90	9,70	82,00
Triglycerides	81,93	99,20	99,20	99,70	81,40
Phospholipids	0,38	0,33	0,20	-	-
Cholesterol	0,19	0,10	0	0	0
B – sitosterol	-	-	0,20	-	0,04
Saturated fatty acids	50,25	39,64	11,30	25,10	17,40
Palmitic Acid	24,61	24,30	6,20	16,80	9,90
Stearic Acid	7,52	12,50	4,10	7,80	7,20
Monounsaturated fatty acids	26,79	45,56	23,80	51,90	42,90
Oleic Acid	22,73	43,00	0	51,00	42,90
Palmitoleic Acid	2,86	2,50	23,50	0,90	-
Polyunsaturated fatty acids	0,91	10,60	59,80	18,40	17,60
Linoleic Acid	0,84	9,40	59,80	18,20	17,60
Linolenoic Acid	0,07	0,70	0	0,20	0
Arachidonic acid	0	0,50	0	0	0

According to: Schuenke, M.D., Herman, J., Staron R.S. (2013).

As it follows from the data presented in the table, most polyunsaturated acids are found in vegetable oils. Sometimes, however, pork bacon is underappreciated. At the same time, it is known to contain a fairly favorable ratio of fatty acids, including polyunsaturated, and even a small amount of arachidonic acid. Pork bacon has a very high nutritional value. But these qualities, in reality, are manifested if the animals have been fed correctly: their food must contain unsaturated fatty acids (pomace, sunflower seeds, acorns, etc.).

Vegetable oils are useful, but the body also needs animal fats. Various nutritional guidelines recommend that the ratio of animal and vegetable fats be 70:30 or 50:50.

Margarine, cooking fats, mayonnaise are prepared, in the food industry, from vegetable oils. Margarine is usually obtained by hydrogenation, that is, part of the unsaturated acids are transformed into saturated acids, which allows to obtain a product in a solid state. Unfortunately, in this process, some vitamins are also destroyed, especially tocopherols (vitamin U). The nutritional value of margarine products is restored with the help of natural fat and oil supplements. When using margarine, it is necessary to carefully study the accompanying documents regarding the ingredients it contains. The same remark applies to mayonnaise and cooking fats.

Naturally, dietary lipids are also evaluated according to the content of fat-soluble vitamins (A, D, E). In the mass media, in popular publications and in the recommendations of many "experts", it is insisted that the consumption of certain fats (butter, lard, etc.) is inadmissible because of the danger posed by cholesterol. At the same time, it is known that, in moderate amounts, cholesterol is necessary. The problem of cholesterol will not be analyzed in the present work, but, in general, it has meaning in the case of real disorders of cholesterol metabolism, a fact that belongs to the competence of doctors.

From a nutritional point of view, however, vegetable oil, especially sunflower oil, contains β-sitosterol, which is a cholesterol antagonist (see Table 1).

When developing rational diets, meat and meat products are analyzed primarily from the point of view of their protein value. At the same time, it should not be ignored that these products contain quite large amounts of lipids (fats). The largest amount of fat is found in processed (prepared) products: salami, sausages, fried pork, etc. In these foods, the amount of fat is twice as much as protein.

If a dietitian develops a diet, through which he aims to saturate the body with valuable fats through the consumption of meat, then, without a doubt, pork would be preferable. Beef and mutton are less valuable.

Fats from poultry and eggs have much better characteristics (Table 2).

Table 2. Lipid content of poultry meat and eggs, g per 100g

The substances	**Broiler**	**Goose**	**Hen**	**Canned chicken**	**Chicken eggs**
Total lipids	14,4	14,6	8,8	9,9	11,50
Triglycerides	11,9	13,9	8,0	9,0	7,45
Phospholipids	2,48	0,57	0,75	0,8	3,4
Cholesterol	0,03	0,04	0,04	0,05	0,57
Saturated fatty acids	3,7	3,7	2,1	2,7	3,0
Monounsaturated: Palmitoleic	1,1	0,7	0,5	0,6	0,4
Oleic	4,6	4,9	3,3	3,2	4,1
Polyunsaturated:	2,0	2,6	1,5	1,6	1,1
Linoleic					
Linoleinic	0,2	0,1	0,1	0,1	0,06

Peanut	0,05	0,04	0,09	0,05	0,10

According to : Schuenke, M.D., Herman, J., Staron R.S. (2013).

From Table 2 it follows that poultry meat contains quite a lot of indispensable polyunsaturated fatty acids: several times more than in beef or mutton. Eggs have a rich content of phospholipids, especially lecithin, but also cholesterol. However, thanks to the high content of phospholipids (=6:1), the negative (atherogenic) action of cholesterol is neutralized.

What is to be analyzed in the lines below seems to be well known, however, we consider it necessary to review some aspects. Only chicken eggs are allowed and recommended. It is desirable that only the so-called fertilized eggs with bright-colored yolk (from reliable rural poultry enterprises) be consumed. Quail eggs are also good for consumption. Some of the biological effects of quail eggs, so far, have not found true confirmation. Due to the danger of salmonella contamination, the consumption of goose and duck eggs is not recommended.

Sporadically, there are "trend" diets that consist of eating raw eggs. Raw egg white contains two antimetabolites: avidin, which prevents the absorption of B_1 vitamins and H (biotin) in the digestive system, ovomucoid, which is an inhibitor of the enzyme trypsin. Even short-term boiling or steaming of eggs can neutralize the antimetabolic effects of avidin and ovomucoid.

Individual intolerance to eggs should also be taken into account. Some people are allergic to egg white, especially if this valuable product is consumed in excess. Usually no more than one egg per day is recommended.

Fish and seafood are also important sources of lipids. In fish, fats are mainly found in the subcutaneous tissue and in the liver. The fat composition is exclusively beneficial: ≈5% polyunsaturated fatty acids, including double, triple unsaturated. The fat of some fish species contains arachidonic acid. In essence, the problem boils down to the difficult access to such products, the lack of variety, the dubious quality of fish and, above all, seafood.

Conclusions:

During recovery periods, especially during competitions that last several days, it is also necessary to restore fat substrates, for the following reasons: a) it is necessary to restore, with the help of food, the gigantic energy expenditure (> 6-7 thousand kcal); b) lipids in food are more easily involved in energy metabolism; c) the coverage of high energy demands, from a physical point of view (according to the volume of food consumed), can be ensured on account of products with a higher energy capacity. Therefore, during such efforts, higher proportions of fat are inevitably introduced into the food rations.

Thus, aspects regarding the nutritional value of lipids must be analyzed as a whole. We must take into account, simultaneously and in a complex manner, the many functions they perform in vital processes: ensuring energy reserves, regulating body temperature, protection against the action of mechanical factors, the absolutely indispensable character of some of them in plastic processes (cell membranes and other structures), the exchange of substances and the biosynthesis of the most important mediators (prostaglandins and other biogenic mediators).

Food sources of lipids are characterized by a content that requires the obligatory combination of different lipids. The rational combination of food of animal and vegetable origin allows the complete satisfaction of the above-mentioned requirements.

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